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ABSTRACT

This document contains four papers on aeronautics education, research, and partnerships that partly supported through the Aeronautics Education, Research, and Industry Alliance (AERIAL). The paper "2002 AERIAL Monograph" (Brent D. Bowen, Jocelyn S. Nickerson, Mary M. Fink, et al.) presents an overview of research and development in the following areas that is being conducted by the National Aeronautics and Space Administration (NASA) Nebraska Space Grant Consortium: spaceports; aviation safety; the Nebraska Native American Outreach Program; and geospatial research. "Airborne Remote Sensing (ARS) for Agricultural Research and Commercialization Applications (White Paper)" (Ram Narayanan, Brent D. Bowen, Jocelyn S. Nickerson) discusses the integration of aerospace technology enterprise applications at the Nebraska Remote Sensing Facility with other NASA enterprises as a model of cross-enterprise transfer of science with specific commercial applications. "Validated Numerical Models for the Convective Extinction of Fuel Droplets (CEFD)" (George Gogos, Brent D. Bowen, Jocelyn S. Nickerson) reports on a transient numerical model that was developed to study the combustion of suspended and moving fuel droplets. "The Small Aircraft

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Transportation System (SATS): Research Collaborations with the NASA Langley Research Center" (Scott E. Tarry, Brent D. Bowen, Jocelyn S. Nickerson) describes efforts to develop innovative solutions to various air transportation problems. Two papers contain substantial bibliographies. (MN)

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UNOAI Report 02-7

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The Aeronautics Education, Research, and Industry Alliance (AERIAL) 2002 Report

Brent D. Bowen
Mary M. Fink
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November 2002

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2002 AERIAL MONOGRAPH
A NASA Nebraska Space Grant & EPSCoR Sponsored Initiative

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Introduction

The NASA Nebraska Space Grant Consortium (NSGC) & EPSCoR programs at the University of Nebraska at Omaha are involved in a variety of innovative research activities. Such research is supported through the Aeronautics Education, Research, and Industry Alliance (AERIAL) and collaborative seed funds. AERIAL is a comprehensive, multi-faceted, five year NASA EPSCoR initiative that contributes substantially to the strategic research and technology priorities of NASA while intensifying Nebraska's rapidly growing aeronautics research and development endeavors.

AERIAL includes three major collaborative research teams (CRTs) whose nexus is a common focus in aeronautics research. Each CRT – Small Aircraft Transportation System (SATS), Airborne Remote Sensing for Agricultural Research and Commercialization Applications (ARS), and Numerical Simulation of the Combustion of Fuel Droplets: Finite Rate Kinetics and Flame Zone Grid Adaptation (CEFD) – has a distinct research agenda. This program provides the template for funding of new and innovative research that emphasizes aerospace technology.

All three CRTs contain similar strategies for intense NASA collaborations, junior faculty development, student assistantships, public outreach, and technology transfer. Each has direct relevance to the state's economic development as well as near- and long-term potential for the aerospace industry. Several factors were weighed when selecting the CRT components for inclusion in AERIAL. These factors include research team responsiveness, ties to NASA researchers, potential contributions to aeronautics research, strength of proposed collaborations, and history of successful products. These teams are discussed in greater detail throughout this monograph.

Separately and collectively, the research, infrastructure-building, and outreach components of AERIAL complement the stated goals of NASA, national and Nebraska EPSCoR, and the NSGC. AERIAL mirrors the priorities of the State of Nebraska's Department of Economic Development and several state-wide, long-range technology and industry plans. AERIAL draws upon the historically productive relationships between and among these organizations to create a program of NASA-driven research and infrastructure strengthening, junior faculty development, and industrial development. It includes innovative marketing approaches to technology transfer and actively involves industry in all facets of its implementation. In direct response to an on-going NASA directive, AERIAL incorporates Public Outreach and Education that focuses on Nebraska's under-represented Native American population.

The NSGC plays a critical role in AERIAL's operation. Rather than duplicating efforts, the NSGC continues to support initial seed funding for junior researchers that could lead eventually to larger funding awards through AERIAL. The NSGC's educational outreach component will be a conduit for the dissemination of AERIAL research outcomes to youth throughout the state. The consortium's ongoing Native American student and teacher outreach initiatives dovetails and facilitates AERIAL's family-based science component for Native American youth.

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The AERIAL goals encompass a variety of research-based activities. Those include, but are not limited to; the advancement of research endeavors among Nebraska faculty members, the expansion of Nebraska's long-term capacity to develop new aeronautics research activities, and the fostering of sustainable growth in aerospace-related industry and the state's economic development. AERIAL's objectives ensure the continuance of high quality research and technological advancements both within Nebraska and throughout the nation.

Nebraska utilizes core funding to broaden AERIAL's impact beyond the individual parameters of the three collaborative research team (CRT) components. Core funding is utilized for two purposes: (a) to foster the initiation of new contacts with NASA Field Centers and Enterprises and to support the collaborative relationships between Nebraska and NASA researchers in areas outside of the three research components; and (b) to build additional human and information infrastructure that ensures the sustained growth of the state's aeronautics research and industry after NASA funding ends.

Those involved in planning for the expansion of AERIAL's activities recognize the contribution that junior researchers can make and therefore seek to utilize their talents and skills. AERIAL's investment in junior faculty members results in a broad foundation of successful aerospace research. Additionally, its activities provide permanent organizational resources that play a vital role in the Nebraska's on-going efforts to expand its research activities.

Emerging Areas of Research

The emerging areas of research are an outgrowth of required seed research funding. The following items have emerged from Year 1 allocations and will grow in Year 2. It is envisioned that three new CRTs will be formed in Years 4 and 5 as a result of EPSCoR and Space Grant seed research initiatives. Seed funding is primarily used to develop new research areas, establish contacts at NASA centers, and to fund graduate and undergraduate researchers in similar research endeavors.

Spaceports

The AERIAL-sponsored research team investigating spaceports consists of Principal Investigator, Dr. Richard Box, Program Director, Dr. Brent Bowen, and Ph.D. student and graduate research assistant, Patrick O'Neil. The overall theme of the project provides research assistance to NASA's program for privatizing spaceport operations and making space launches more frequent, economical, and reliable. This research identifies NASA's research needs, forms relationships with NASA's Kennedy Space Center (KSC), and outlines research activity for following years. This research team is actively involved in the Advanced Spaceport Technology Working Group (ASTWG) and with the National Coalition of Spaceport States. This involvement includes dissemination of information with the above groups, participation in teleconferences, and travel to meetings with members and staff of KSC. Dr. Bowen coordinates collaboration between the spaceport research team and NASA Space Grant and EPSCoR programs. O'Neil is establishing relationships with a number of key people and compiling information on the spaceport-related activities of states and NASA. Additionally, Box and

O'Neil participated in the ASTWG semi-annual conference at KSC in January 2002. Dr. Gale Allen has remained the Spaceport team's liaison to KSC. Follow-up activities include work with NASA staff to shape a vision for research projects in academic year 2002-2003.

The Spaceports team continues to support NASA's commercialization of the space launch initiative. This team also seeks ways in which to participate on NASA Center committees, collaborating with NASA staff and other federal, state, and private sector organizations to identify research needs related to the initiative.

Five research areas are being pursued in the spaceport project's second year. First is the summary of market studies on orbital space launch. The Commerce and Business Development sub-group of the ASTWG has asked UNO to summarize the various reports produced by federal agencies and consultants on the economics and feasibility of commercial space launch. This research area reports summarizing contents of market studies of orbital launch.

The second research area creates an information management and evaluation system. The KSC process for initiating commercialization of space launch is complex and decentralized. The end result may be a new model of public-private partnering useful in other areas of governance. This area of research documents the process to date and allows on-going collection of materials for NASA staff to assess progress and researchers to study implications for other programs.

The third research area involves market analysis of sub-orbital launch potential. Several participants in KSC working groups, especially those from state space authorities, are interested in the potential uses of launch to sub-orbital space, which can be less expensive than orbital launches and could occur in landlocked as well as in coastal locations. Market analysis involves interviews and surveys of people in organizations nationwide and internationally, and analysis of economic data. This research area is developing a detailed report on the market potential of sub-orbital space launch.

The fourth research area monitors technology research needs. As part of the KSC transition to a research and development role, research needs are emerging in advanced technological areas. Monitoring technology activity involves working with KSC staff to identify research needs that may be addressed by faculty of the University of Nebraska at Lincoln (UNL) College of Engineering and Technology.

The final research area involves the conceptual development and expansion of a specific educational outreach component. Spaceports project staff are conceptualizing opportunities for educational and research activities for implementation in following years.

The team collaborates with NASA KSC staff and coordinates with NASA's Marshall Space Flight Center, the U.S. Dept. of Commerce Office of Space Commercialization, state space-related programs involved in the sub-orbital market research activity, and the UNL College of Engineering and Technology. It also collaborates in research work with the State of Alabama Aerospace Development Center, the National Coalition of Spaceport States, and the Idaho Space Grant Consortium.

Aviation Safety

NASA Langley is leading the NASA Aviation Safety Program, which is supported by NASA Ames, Dryden, and Glenn Research Centers. This program is conducted in partnership with the FAA, other government agencies and the aerospace industry to develop technologies that support a national initiative to reduce the fatal aircraft accident rate by 80 percent in 10 years, and by 90 percent in two decades. The intent of this goal is to meet the President's challenge to improve aviation safety. This program, which utilizes information technology to build a safer aviation system, was created in 1997 in response to a report from the White House Commission on Aviation Safety and Security. NASA responded by forming the Aviation Safety Investment Strategy Team (ASIST) with industry, government, and academia participation in defining aviation safety research needs. The ASIST findings provided the foundation and rationale for formulation of the NASA Aviation Safety Initiative. The program also is part of the "Three Pillars for Success" initiative that spells out what NASA will do to achieve national priorities in aeronautics and space transportation technology.

The Nebraska AERIAL team has responded to the needs of aviation safety as well. A meeting was held at Mahoney State Park on October 9, 2001 to discuss aviation safety as a collaborative research possibility for the Nebraska AERIAL researchers. Minutes from the meeting can be found in Appendix A. As a result of this meeting, two UNL researchers were awarded external funding. Kevin Cole is conducting a study entitled "Pulse-heated Hot-film Sensors for Aerodynamic Measurements." Collaborations between Cole and NASA's Dryden Flight Research Center and Langley Research Center are currently being pursued for the future. Dr. Steve Goddard is working on "Improving Aviation Safety through Real-Time, Spatio-Temporal Resource Allocation."

The AERIAL team continues to respond to the needs of aviation safety in correlation with the NASA Aviation Safety Program. Dr. Brent Bowen and Dr. Samy Elias lead this essential team of researchers. The issues discussed at the October 9, 2001 meeting have been analyzed and collaborative research on aviation safety is now pursued. The research areas spawned by this meeting will continue to be supported.

Nebraska Native American Outreach Program (NNAOP)

One of the most significant accomplishments for Nebraska in its NASA activities is the creation and implementation of its Nebraska Native American Outreach Program (NNAOP). This initiative was launched in direct response to NASA's emphasis on the inclusion of underrepresented populations in NASA EPSCoR and Space Grant funded activities. NNAOP inspires Native American youth from Nebraska to pursue academic and professional careers in the aeronautics and aerospace fields. Activities to date include: (a) the Native American Working Group; (b) an annual Aeronautics Day for Native American youth; and (c) initiation of an underrepresented student scholarship program. The Family Science Project: Families United (FUN) in the Discovery of Mathematics, Science, and Technology was also created through the NNAOP and continues its successful mission at Santee, Walthill, Macy and Winnebago public schools. Family Science provides an opportunity for families to work together in simple

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scientific inquiry that demonstrates that science is a fundamental component of everyday lives. Key activities are the development of instructional discovery units (family science units) based on weather and climate, aeronautics, space science, and other scientific areas. These events also provide an opportunity for CRT representatives to introduce Native American students to the innovative research that is being conducted through AERIAL. The underlying goal is the continued improvement of mathematics and science skills among these Native American youngsters.

On Saturday, December 8, 2001 the NSGC & EPSCoR Programs and the Aerospace States Association (ASA) sponsored the first Nebraska Aeronautics Education Summit (NAES) Meeting, which was held in South Sioux City, Nebraska near the state's tribal lands. This event was organized to seek a common vision between educators of students in grades K-12 from four Native American high schools and two tribal colleges. Numerous presentations have been made, interfacing between schools has begun, administrative leadership conferences have been held, and NASA data and models have been utilized to improve mathematics and science programs in Native American public schools. The accomplishments that this program has achieved provide the guidelines for implementation of such programs in other states throughout the nation.

A variety of disciplines and institutions were represented at the Summit. Those present included educators and administrators from Nebraska's four Native American public schools and two tribal colleges, university faculty from several Nebraska institutions, researchers, and industry representatives, among others. This diverse group of individuals provided a unique opportunity to gather information regarding the effectiveness of the NNAOP. A complete communiqué of the Summit meeting may be found in Appendix B.

Geospatial Research

AERIAL researchers have discovered a unique opportunity to complement the educational outreach activities that are already taking place with Nebraska's Native American community. The AERIAL NNAOP personnel continue to support Native American education in Nebraska by incorporating new geospatial technologies into the predominantly Native American classrooms. The tribal organizations lack the necessary personnel to design and deliver math, science, and technology programs on site. AERIAL has allowed for the implementation of a 'specialist position' that is not only aid in filling the gap of technologically focused personnel, but also implement this unique and substantive geospatial opportunity.

This geospatial research team creates another collaborative research area between the UNO and UNL, which will be initiated by Nebraska's Native American Tribal Colleges. The first implementation steps of the geospatial research team include developing skills, demonstrating usefulness to the community, incorporating this specialized research into curriculum, etc. The data that is collected through geospatial research will complement the work that is progressing through the ARS CRT.

Progressive Research

The research sponsored through the NSGC & EPSCoR programs is becoming progressively more critical to Nebraska's economy, more essential to educational success in Nebraska's Native American community, and more collectively vibrant throughout the aerospace fields of research. The quality of the CRT and seed research endeavors continues to improve steadily. Such high levels of success have prompted more substantial areas of research to surface and subsequently are funded. The emerging areas of research are seen as sound contributions to the advancement of their experimental areas. Additional contributions as well as descriptions of current investigations can be found in the following overviews.

Appendix A

NASA Aviation Safety Collaborative Research Meeting
October 9, 2001
Mahoney State Park, Red Oak Room

Attendees:

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Opportunities:

- Seed research grants are available immediately.
- Priority will be given to applications received prior to October 31, 2001.
- Applications are available at: http://www.unomaha.edu/~nasa/funding/seed.htm
- Funding can be used for relationship-building with researchers at NASA Centers, summer funding, student support, etc.
- Waived indirect can be used as match (not including fringe benefits).
- Additional $3,000-$7,500 may be available for top grad student funding from Dean Hendrix (UNL).
- Potential for seed research to grow each year & reach Collaborative Research Team (CRT) status in 4-5 years through NASA EPSCoR funding.
- Nebraska houses three of the top twenty national design firms: make connections (Waters).
- Collaboration opportunities with PKI's dedicated, 4-year technology transfer specialist from the US Army Corps of Engineers.

Initiatives:

1. Aviation Safety
2. Spaceport Development
   a. Systems Working Group
   b. Range Technology/ Facilities
   a. Consider industry involvement

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Appendix B

NASA Nebraska Space Grant & EPSCoR / Aerospace States Association
Nebraska Aeronautics Education Summit Meeting
"The Role of Aeronautics and Space in Native American Education: Evaluation and Visioning Analysis"

Communiqué

Background

On Saturday, December 8, 2001 the NASA Nebraska Space Grant (NSGC) & EPSCoR Program and the Aerospace States Association sponsored the first Nebraska Aeronautics Education Summit (NAES) Meeting, which was held in South Sioux City, Nebraska near the state's tribal lands. This event was organized to seek a common vision between educators of students in grades K-12 from four Native American high schools and two tribal colleges. Dr. Henry Lehrer, the NSGC Native American Outreach liaison, began the discussion with an overview of the many activities that have taken place since the inception of Nebraska's Native American Outreach program five years ago. Numerous presentations have been made, interfacing between schools has begun, administrative leadership conferences have been held, and NASA data and models have been utilized to improve mathematics and science programs in Native American public schools.

A variety of enrichment activities have taken place at Nebraska's two Native American colleges, Little Priest Tribal College and the Nebraska Indian Community College, to support their students, faculty and staff. The Native American Outreach Program has assisted in faculty development, aided administration in enhancing curriculum, and developed institutional guidelines for better preparation of students in the sciences. This team of motivated individuals has already begun taking steps toward assisting these colleges in better equipping their science labs.

However, achievements have not been limited to the college level. Nebraska's Native American school systems, comprised of Omaha Nation, Walthill, Winnebago, and Santee, have also participated in many educational events and activities. Those include:

- Eight teachers have attended the annual two-week NASA Ames Summer Workshop;
- Nearly 1,000 5th grade students have been involved in the annual Aeronautics Day at Sioux City Airport;
- Santee students attended the annual Aviation Career Education (ACE) Academy sponsored by the Nebraska Department of Aeronautics; and
- The Family Science program has been introduced and will be functioning at all schools in 2002.

The accomplishments that this program has achieved provide the guidelines for implementation of such programs in other states throughout the nation.

Technique

A variety of disciplines and institutions were represented at the Saturday event. Those present included educators and administrators from Nebraska's four Native American public schools and two tribal colleges, university faculty from several Nebraska institutions, researchers, and industry representatives, among others. This diverse group of individuals provided a unique opportunity to gather information regarding the effectiveness of the NSGC Native American Outreach program. This was done by employing a focus group research technique. Those present were divided into three groups led by Dr. Ed Zendejas, Ms. Michaela Schaaf, and Ms. Mary Fink. Each group provided valuable opinions and suggestions for refining this extraordinary program. Dr. Henry Lehrer served as overall focus group moderator.

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The four questions that each focus group was asked to answer were stated as follows:

1. Is the use of NASA-based aeronautics and space to teach mathematics, science, and technology a viable motivator of Native American youth, particularly at-risk students?
2. Can Family Science make a difference and how can the concept be streamlined? Has the ASA sponsored Family United (FUN) in the Discovery of Mathematics, Science, and Technology initiative been effective?
3. Should there be a continuous NASA-based science and mathematics track from elementary/secondary to tribal college?
4. How should the UNO Aviation Institute and the Nebraska NASA Space Grant & EPSCoR proceed in the coming years to better serve the students, faculty, and staff of the state's 4 reservation schools and 2 tribal colleges?

Results

After all questions had been addressed by the focus groups, the summit was reconvened and recommendations from each group compiled. A variety of superior suggestions were brought to the table for discussion. The following is a list of key recommendations that were offered and that the Native American Outreach program is now addressing.

NAES Focus Group Recommendations:

1. Staff development could be increased in Native American schools by addressing scope and sequence through training and regular faculty and staff meetings.
2. Engage teachers in research and inquiry to involve them in the gathering of information and to allow them to experience tangible results.
3. Integrate Native American culture and values into the NASA sponsored programs to ensure not only that the students are aware of their heritage, but also to provide consistency between school and home.
4. Cultivate and promote Native American administration and partnerships with NASA as advised by the Presidential Executive Order.
5. Develop a partnership format between the Native American schools and the grant agency that will promote equally beneficial outcomes.
6. Create a Space Grant facility to be staffed by professionals in the Native American community.
7. Communicate the importance of Native American Outreach program awareness to teachers and administrators through promotion and visibility.

After a post-facto review of the recommendations, these results were released to the public, media, and all interested organizations and individuals.

Elaboration

The Native American elementary schools, secondary schools and colleges with which our Outreach Program is working, are in need of many resources for technological and educational advancement. Additionally, the need for integration between all levels of schooling is imperative to ensure reinforcement of educational information and to provide a tracking process for students interested in mathematics and science. The Native American culture is one that promotes community involvement and awareness. The Family Science program integrates this involvement into the schools by providing a positive environment for families to learn together through science-based activities. The primary focus of this program is to get students to become more interested in mathematics and science through the use of airplane and rocket Study units. This program, which is already in place in many of the Native American public schools, is flourishing. The NSGC & EPSCoR Program seeks to continue such programs and provide the development and enhancement of additional community-wide educational opportunities. Future plans include:

- Developing elementary and secondary school mathematics and science courses as "feeder programs" for colleges and universities;

- Using distance education to reach non-traditional collegiate students;
- Creation of a summer mathematics institute for recent high school graduates;
- Providing science field trips and summer science camps;
- Designing a Native American Aeronautics Education Outreach website; and
- Increasing community involvement and awareness through a unique banner program.

Resulting Vision

The Native American Outreach Program is focused on making Native American students more competitive in mathematics and science. Whether this is done through providing additional scholarships and fellowships or through cultivating the relationships being established between educators and NASA, the program is a prime example of prophetic thinking and planning. Those involved in the Nebraska Aeronautics Education Summit meeting participated in this forward thinking by offering their ideas and contributing their expertise. Although the culmination of the first five years of this successful program has taken place, the collaboration provided by the summit participants gives vision for many years to come. Those in the ASA, the NSGC & EPSCoR program, the Native American schools and the community look forward to experiencing the same high level of achievement in the future.

AIRBORNE REMOTE SENSING (ARS) FOR AGRICULTURAL RESEARCH AND COMMERCIALIZATION APPLICATIONS

(White Paper)

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Abstract

Tremendous advances in remote sensing technology and computing power over the last few decades are now providing scientists with the opportunity to investigate, measure, and model environmental patterns and processes with increasing confidence. Such advances are being pursued by the Nebraska Remote Sensing Facility, which consists of approximately 30 faculty members and is very competitive with other institutions in the depth of the work that is accomplished. The development of this facility targeted at applications, commercialization, and education programs in the area of precision agriculture provides a unique opportunity. This critical area is within the scope of NASA goals and objectives of NASA's Applications, Technology Transfer, Commercialization, and Education Division and the Earth Science Enterprise. This innovative integration of Aerospace (Aeronautics) Technology Enterprise applications with other NASA enterprises serves as a model of cross-enterprise transfer of science with specific commercial applications.

AIRBORNE REMOTE SENSING (ARS) FOR AGRICULTURAL RESEARCH AND COMMERCIALIZATION APPLICATIONS
(White Paper)

An Overview of Capabilities

Rationale

Tremendous advances in remote sensing technology and computing power over the last few decades are now providing scientists with the opportunity to investigate, measure, and model environmental patterns and processes with increasing confidence. Much of the underpinning data acquisition for such research is multi-disciplinary and synoptic in scale, be it global or local. Airborne remote sensing of the earth is playing an increasing role in the support of fundamental research into the natural environment and its inherent physical, biological, and chemical processes. Furthermore, airborne remote sensing considerably extends the capabilities of traditional satellite remote sensing in terms of resolution and operational planning by providing better spatial accuracies and opportunities for timely monitoring.

The University of Nebraska-Lincoln's (UNL) remote-sensing program and the University of Nebraska at Omaha Aviation Institute (UNOAI) have cooperatively developed the Nebraska Remote Sensing Facility. The remote-sensing program at UNL consists of approximately 30 faculty members and is very competitive with other institutions in the depth of the work that is accomplished. The University of Nebraska at Omaha (UNO) has a strong aviation science and technology program which facilitates the facility air operations for the project. The combined strength of these two institutions creates a unique specialty that will be a resource not only for Nebraska, but also for the entire nation.

The development of an airborne remote sensing facility targeted at applications, commercialization, and education programs in the area of precision agriculture provides a unique opportunity. This critical area is within the scope of NASA goals and objectives of NASA's Applications, Technology Transfer, Commercialization, and Education Division and the Earth Science Enterprise. This innovative integration of Aerospace (Aeronautics) Technology Enterprise applications with other NASA enterprises serves as a model of cross-enterprise transfer of science with specific commercial applications.

Nebraska ARS Collaborative Research Team (CRT)

The Nebraska NASA EPSCoR program at the UNOAI currently provides support for an Airborne Remote Sensing Collaborative Research Team (ARS CRT). This highly skilled team of researchers operates the Nebraska Remote Sensing Facility through which a variety of technological advancements are being made. The ARS CRT is highly productive in its research endeavors, providing multi-institutional and inter-disciplinary research opportunity for Nebraska.

The UNOAI has designated a Flight Operations Coordinator for the ARS facility who oversees administrative operations of the aircraft including flight policy, fiscal issues,

dispatching, and personnel. The Flight Operations Coordinator supervises start-up and actual flight operations including daily logistics, all piloting, safety programs, and coordination with the Nebraska Department of Aeronautics, Federal Aviation Administration, other agencies, and maintenance facilities. An air operations research specialist (pilot) conducts the actual research flights in the aircraft. Pilot interns, provided by the UNOAI, serve as co-pilots to assist research operations and provide additional safety. The acquired aircraft is based out of the Omaha Millard Airport where hangar and office facilities are provided to support operations management by the UNOAI. ARS research investigators determine the priority of research mission requests and, in conjunction with the Flight Operations Coordinator, establish the schedule and logistics of the flight. Safety of the mission is the highest priority and is determined by the pilot and the Flight Operations Coordinator.

This facility also fosters close interaction between the university and industry as well as government agencies nationwide. There is currently no university within the United States that operates a full-time airborne remote sensing platform. Since remote sensing technology is poised to enter the commercial market in the near future, the advantage of such a facility will benefit not only the conduct of high-quality research, but also help spawn spin-off companies designing novel low-cost airborne sensor systems. This result provides opportunity for commercialization of research and immediate transfer of technology.

Current Research

The ARS CRT's current research efforts include a variety of projects. The first involves the current suite of operational instruments. These instruments are being calibrated and validated. Calibration is performed using standard surface targets (with known reflectance characteristics, such as concrete, tarpaulin, etc.) for optical and laser sensors, and active and passive corner reflectors for radar sensors. The calibration is performed under different environmental conditions, with the information being saved for use while analyzing data. The validation procedure is required in order to make sure that the calibrated sensors provide meaningful data when used to measure the reflectance of known terrain and vegetation. Issues such as noise contamination and dynamic range limitations are being studied and methods to overcome these problems are being developed.

The ARS CRT is also performing comprehensive airborne data collection and data analysis. Data is being collected over crops and vegetation at the Mead Test Site in Mead, Nebraska. The [illegible]n is also taking concurrent ground measurements of vegetation biophysical properties and underlying soil parameters, such as leaf area index (LAI), crown cover, leaf water potential, and soil moisture. ARS is developing forward and inverse models to analyze the data. The forward models are developed first to predict the reflectance from a given set of crop and soil conditions. Using comprehensive simulation, the inversion models are being developed to obtain vegetation and soil properties using remote sensing data. The models will be refined using actual data acquired by the ARS CRT sensors.

Current plans include the development of a detailed study and analysis of various error sources, some unique to airborne remote sensing. This will aid in understanding their impact on

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the retrieval of biophysical and soil properties using the ARS CRT inversion algorithms. These include instrument noise, aircraft pointing errors, and calibration uncertainty, among others.

Additionally, the ARS CRT has developed microwave scattering models for natural media to analyze scatterometer and SAR measurement data and retrieve target biophysical parameters. This includes the development of a four-component microwave scattering model. First, the generalized Rayleigh-Gans (GRG) approach, the physical optics (PO) approach and the Bridging approach between the quasi-static and physical optics approach (GRG-PO) for disk scattering amplitude formula are compared. Additionally, the PO approach is being extended from a circular disk shape to an elliptic disk shape, which better mimics a natural leaf in the crop. Then, the corrected cylinder scattering amplitude formula and the original formula presented by Karam et al. for the stem are compared and analyzed. Finally, a precise numerical computation algorithm is being developed to combine radiative transfer theory with theoretical simulation of scattering. The model can be applied over a broad frequency range. In other words, the GRG approach is applied at low frequencies, while the PO approach is applied at high frequencies. Furthermore, theoretical simulation based on the improvement mentioned above is conducted for scattering from corn canopies.

Data Acquisition

The collaboration between UNL and UNO, seen through the ARS CRT, provides a unique opportunity to utilize the capabilities of UNOAI's single-engine Piper Saratoga. This aircraft gives UNL's remote-sensing scientists a ready-at-hand airborne platform and provides the UNOAI with advanced aviation technology applications for educational support. University ownership of an aircraft equipped with key sensors allows flexibility in data acquisition and demonstrates significantly enhanced precision.

The Saratoga was modified to accommodate the ARS CRT's remote sensing equipment. The following sensors serve as equipment on the aircraft:

- Kodak DCS-420 color-infrared digital camera
- Analytical Spectral Devices (ASD) spectroradiometer operating in the 350-2500 nm wavelength range
- NASA Goddard Space Flight Center provided and refurbished Airborne Laser Polarimeter System (ALPS) operating at 532 and 1064 nm wavelengths
- UNL developed noise radar scatterometer operating at 1.275 GHz (L-band) and 10 GHz (X-band) frequencies
- Canon 2500 digital video camera

A major goal is to enhance the ways in which airborne remote sensing technology can be utilized in agricultural applications, with special consideration given to applications involving precision agriculture. In order to be used in a practical manner for precision agriculture, remote sensor systems possess the following characteristics:

- spatial resolution (on the ground) of five meters or less

- two- or three-day repeat cycle
- spectral coverage in at least the green, red, near-infrared portions of the spectrum (mid-infrared is desirable), as well as in the microwave regime
- data distribution in near-real time and at low cost

A state-of-the-art AISA hyperspectral imager, operating over the 400-900 nm wavelength range, has been purchased and is being integrated within the Piper Saratoga. This sensor was calibrated at the NASA John C. Stennis Space Center, Mississippi, in February of 2002, and flown over selected sites in Southern Mississippi including the delta region and coastal areas in the Gulf of Mexico.

Construction of the multiwavelength lidar system has also been completed and the ARS CRT is currently performing preliminary field tests and calibration of the system. This multiwavelength lidar system will also be incorporated into the onboard aircraft equipment. This system employs a Nd:YAG laser which emits radiation at two wavelengths: the fundamental at 1064 nm and the frequency-doubled at 532 nm. Both laser beams are highly linearly polarized (100:1 extinction ratio) and have a beam divergence angle of 4 mrad. The receiver consists of four channels: two for each wavelength. Each wavelength contains one channel to measure co-polarized backscatter and one channel to measure cross-polarized backscatter. In addition to the polarimetric information that can be gathered, the lidar system also has ranging capability. Thus, the ARS CRT's lidar system is capable of performing studies of vegetation canopy structure as well as characterization of vegetation depolarization.

The ARS CRT has designed the Synthetic Aperture Radar (SAR), which is currently being tested at the Nebraska Remote Sensing Facility. Additionally, investigations are being conducted regarding the packaging method that will be pursued when the SAR is mounted within the Saratoga's remote sensing equipment. The SAR is one of the main tools for microwave remote sensing because of its multi-dimensional high-resolution imaging capability and its ability to operate in nearly all weather conditions, day and night.

The SAR system is an X-band, stepped-chirp FM, single polarization radar system. One of the unique features of the system is that the signal generation consists of a timing-controlled D/A converter and VCO arrangement to generate the stepped-chirp signal, thereby allowing for less design complexity and lower overall system cost. The individual block segments including waveform generation, transmit and receive hardware, antennas, quadrature detection and image signal processing have been finalized. The microwave system of the SAR has been designed and constructed and is currently under calibration and testing. The system is undergoing field tests from a 10-meter high van-mounted boom on a variety of terrain types. The following experiments have involved use of the SAR:

- Theoretical efforts have been commenced to model the microwave as well as optical scattering from leaves and crop canopies;
- Theoretical explorations have been commenced to understand the limitations of interferometric SAR (InSAR) and various design methodologies; and

- New data has been obtained regarding femtosecond fluorescence characteristics of single leaves, thus, various options for the design of the laser fluorescence sensor for crop stress monitoring are being explored.

In addition to the above, the ARS CRT is investigating new sensor development. This includes the interferometric SAR (InSAR) and the laser fluorescence sensor. This team is working aggressively to develop and test these two sensors. Initial analytical and experimental study has provided us with the necessary information on the major issues involved in the development of these sensor systems. The ARS CRT is exploring various options for the design of the laser fluorescence sensor for crop stress monitoring. Preliminary designs are underway and the development and initial testing of these sensors is expected to be completed within the next year.

Specialized Airborne Capabilities

- Aircraft platforms provide a unique mechanism for obtaining data and images at very high spatial resolution, which is required for site-specific management in agriculture.
- Airborne data can be acquired at precisely specified, often critical, times during the growing season.
- Aircraft platforms provide opportunities to deploy commonly available and widely-used sensors such as multi-spectral digital and video cameras. As a result, these platforms test innovative next-generation sensor technologies that are neither currently available on satellite platforms nor are likely to be available within the upcoming decade (e.g., laser reflectometers, imaging spectrometers, laser fluorescence sensors), and to configure arrays of diverse types of sensors as needed.
- Data acquired by means of airborne sensors for agricultural applications can be delivered to producers and managers in near-real time and at low cost.

It is also anticipated that both satellite and aerial remote sensing information can be used to develop better range management, land management, and water quality.

Collaborative Efforts

The ARS CRT conducts monthly meetings in which all faculty and senior personnel present research results and discuss plans for the future. At times, graduate students also attend to present their progress. These meetings provide an opportunity for all researchers to gain insight on other internal research and give constructive comments and suggestions. Thus, the team is able to ensure that the entire project as well as individual sub-projects are progressing steadily.

The ARS CRT is developing relationships with three NASA institutions. Those include: Goddard Space Center in Green Belt, Maryland; the Jet Propulsion Laboratory in Pasadena, California; and Stennis Space Center in Mississippi. More formal collaborations will be sought with these institutions as concrete research results become available. Active collaboration will

commence following airborne remote sensing data collection. Various NASA personnel have expressed interest in this collaboration.

The ARS CRT is actively seeking underrepresented groups to participate in the project. Flyers and announcements are developed to specifically to target these groups and are posted throughout the UNL campus in the near future. Additionally, senior faculty mentor junior faculty and graduate students by discussing research results and providing guidance for research direction. Mentoring also takes place through work on joint research proposals.

Primary Research Applications

One of the ARS CRT's primary foci is the use of airborne remote sensing data for estimating agricultural parameters of interest, such as crop stress and soil moisture. Both these parameters impact the well-being of a large section of the populace and are very relevant to the agriculture-based economy of Nebraska and the Great Plains region. The proposed research and outreach activities are expected to be useful to small farmers as well as large agribusinesses.

Another focus of the team's work is in the area of hail damage to crops. The ability to rapidly monitor hail-damaged areas and estimate the loss would be a tremendous asset to insurance agencies as well as government decision-makers. The ARS CRT is developing the necessary tools using both optical and microwave remote sensing data. In addition, they are exploring ways to estimate the extent of drought and brush-fire hazard regions based upon airborne remote sensing data.

Remotely sensed data hold great potential for use in crop monitoring and diagnostics. In order to analyze and monitor terrestrial vegetation by means of remote sensing, basic research is needed whereby the relationships are unambiguously elucidated between spectral response and biophysical parameters such as vegetation fraction, leaf area index, above-ground biomass, and pigment concentrations. Discovering, identifying, and locating stresses in agricultural crops is a key to both maximizing yield and improving farming efficiency.

The Airborne Remote Sensing Collaborative Research Team project provides an extraordinary opportunity to combine resources through the incorporation of additional aviation-related research. Precise determination of position, velocity and time (PVT) is essential to obtain accurate information about the absolute reflectance characteristics of remote sensing targets. In airborne systems, precision PVT presents a new challenge due to atmospheric conditions, which induce random motion around the aircraft yaw, pitch and roll axes. The precision and reliability of state-of-the-art GPS navigation equipment can be analyzed and enhanced by referencing data acquired from Differential GPS (DGPS) reference stations fixed at precise geodetically surveyed positions. Calibration algorithms can be developed to provide accurate aircraft orientation data to the pilot and allow the airborne sensors to accommodate for the trigonometric errors induced by random motion of the flight. Additionally, the synergism of the remote sensing project and a navigation paradigm incorporating a geographic North versus the traditional magnetic North model will provide both efficient operation and new data to continue research begun by Dr. Mike Larson to study the navigational task performance benefits of using the geographic North model.

Vision, Mission, Objective

Research in remote sensing has already been established as a priority research area at the University of Nebraska. CRT remote sensing research within the University engages numerous units/departments, colleges, and campuses, thus making this a truly multidisciplinary effort. The ARS CRT vision focuses expertise and experience on the technologies of remote sensing, geographic information systems, global positioning systems, real-time aircraft-data reception, and field measurement in agriculture. Although the CRT's primary focus is to conduct basic research, it also emphasizes the practical applications that will or might be linked with private enterprise. In particular, the team is receptive to development of applications in conjunction with associated investigators who represent private companies involved in agricultural applications. This approach seems appropriate given the fact that the economy of the State of Nebraska (and the Great Plains region) is very much oriented to and dependent upon agriculture. The ARS CRT is developing techniques for economic and timely monitoring of the condition of agricultural crops, such as corn and soybean, which form a large portion of the state's economy. A variety of outcomes have resulted from ARS research and can be viewed in Appendix A.

Recent Activities

1. Integration of the following sensors aboard the aircraft and commenced data collection:
    a. Kodak DCS-420 color-infrared digital camera,
    b. Analytical Spectral Devices (ASD) spectroradiometer, and
    c. Canon 2500 digital camera;
2. Purchase of the AISA hyperspectral imager, which has been integrated within the aircraft - data collecting with this sensor has commenced;
3. Construction of the multiwavelength lidar system has been completed and preliminary field tests with this equipment are currently being performed;
4. The synthetic aperture radar (SAR) has been designed and is currently being tested - this system is being packaged to be mounted within the aircraft;
5. Theoretical efforts have commenced to determine microwave and optical scattering from leaves and crop canopies;
6. Theoretical efforts have commenced to understand the limitations of interferometric SAR (InSAR) and various design methodologies are being explored; and
7. New data on femtosecond fluorescence characteristics of single leaves has been obtained, and various designs of the laser fluorescence sensor for crop stress monitoring are being explored.

Further Information

If you would like further information regarding airborne remote sensing, or would like to collaborate with the Nebraska CRT for conducting a mission of your own, please contact:

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Appendix A

Team Outcomes

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VALIDATED NUMERICAL MODELS FOR THE CONVECTIVE EXTINCTION OF FUEL DROPLETS (CEFD)

A NASA Nebraska Space Grant and EPSCoR Sponsored Research Endeavor

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Abstract

The NASA Nebraska Space Grant (NSGC) & EPSCoR programs have continued their effort to support outstanding research endeavors by funding the Numerical Simulation of the Combustion of Fuel Droplets study at the University of Nebraska at Lincoln (UNL). This team of researchers has developed a transient numerical model to study the combustion of suspended and moving droplets. The engines that propel missiles, jets, and many other devices are dependent upon combustion. Therefore, data concerning the combustion of fuel droplets is of immediate relevance to aviation and aeronautical personnel, especially those involved in flight operations. The experiments being conducted by Dr. Gogos' and Dr. Nayagam's research teams, allow investigators to gather data for comparison with theoretical predictions of burning rates, flame structures, and extinction conditions. "The consequent improved fundamental understanding of droplet combustion may contribute to the clean and safe utilization of fossil fuels" (Williams, Dryer, Haggard & Nayagam, 1997, ¶ 2). The present state of knowledge on convective extinction of fuel droplets derives from experiments conducted under normal gravity conditions. However, any data obtained with suspended droplets under normal gravity are grossly affected by gravity. The need to obtain experimental data under microgravity conditions is therefore well justified and addresses one of the goals of NASA's Human Exploration and Development of Space (HEDS) microgravity combustion experiment.

VALIDATED NUMERICAL MODELS FOR THE CONVECTIVE EXTINCTION OF FUEL DROPLETS (CEFD)
(White Paper)

An Overview of Capabilities

Rationale

"The engines that propel missiles, jets, and many other devices are dependent upon combustion. Liquid fuel is sprayed into an engine chamber where it evaporates and burns, generating the thrust that propels the object forward" (Mashavek, 2001, ¶ 1). The amount of thrust created depends on many factors, including pressure, temperature, the fuel droplet evaporation rate, and turbulence. Therefore, data concerning the combustion of fuel droplets is of immediate relevance to aviation and aeronautical personnel, especially those involved in flight operations.

"The combustion of fuel droplets is an important part of many operations, such as the heating of furnaces for materials processing or home heating, power production by gas turbines, and combustion of gasoline in a car's engine" (Williams, Dryer, Haggard & Nayagam, 1997, ¶ 2). The Earth's gravity prevents many theoretical predictions involving fuel droplet combustion. Additionally, drop towers and aircraft are unsuitable for this type of experimentation due to time constraints and unacceptable levels of microgravity. The experiments being conducted by Dr. Gogos' and Dr. Nayagam's research teams, allow investigators to gather data for comparison with theoretical predictions of burning rates, flame structures, and extinction conditions. "The consequent improved fundamental understanding of droplet combustion may contribute to the clean and safe utilization of fossil fuels" (Williams, Dryer, Haggard & Nayagam, 1997, ¶ 2).

The present state of knowledge on convective extinction of fuel droplets derives from experiments conducted under normal gravity conditions. "Due to the increase in the extinction velocity with droplet diameter, under extinction conditions natural convection becomes negligible at large 'droplet' (porous sphere) diameters and important at smaller droplet diameters" (Bowen, Woods, Narayanan, Smith, & Gogos, 2000, 4.3.3 p. 1). As a result, any data obtained with suspended droplets under normal gravity are grossly affected by gravity. The need to obtain experimental data under microgravity conditions is therefore well justified and addresses one of the goals of NASA's Human Exploration and Development of Space (HEDS) microgravity combustion experiment.

NSGC & EPSCoR Background and Research Involvement

The Nebraska Space Grant Consortium at the University of Nebraska at Omaha develops research infrastructure and enhances the quality of aerospace research and education throughout the state. This grant provides national leadership in applied aspects of aeronautics and allows Nebraska colleges and universities to implement a balanced program of research, education, and public service programs related to aeronautics, space science, and technology. The grant administers funds to recruit and train professionals for careers in the aerospace industry.

EPSCoR (Experimental Program to Stimulate Competitive Research) assists states with low levels of federal research and development support, thus responding to a Congressional concern about increasing the geographic base of federal research support. Nebraska EPSCoR is a statewide effort, which provides leadership for development of research and development in science and engineering throughout the state. Specific to the University of Nebraska at Omaha is the Aeronautics Education, Research, and Industry Alliance (AERIAL), a comprehensive, multi-faceted, 5 year NASA EPSCoR 2000 initiative. This contributes substantially to the strategic research and technology priorities of NASA while intensifying Nebraska's rapidly growing aeronautics research and development endeavors.

The partnership between the NASA Nebraska Space Grant (NSGC) & EPSCoR programs allows for the selection of outstanding research projects that positively impact aeronautical technology advancement. These programs have continued their effort to support such research endeavors by funding the Numerical Simulation of the Combustion of Fuel Droplets study at the University of Nebraska at Lincoln (UNL).

The CEFD Concept

Dr. Vehda Nayagam guides the Microgravity Combustion Science Program in San Diego, CA. This program is conducting a project flight definition experiment to obtain data under microgravity conditions. The UNO CEFD collaborative research team (CRT) is developing a new comprehensive numerical model for the convective extinction of fuel droplets to validate this model. The data collected from each institution contributes to one of the long-term goals of the HEDS microgravity combustion program. Specifically, that which promotes "understanding that will permit lessons learned in microgravity combustion experiments and modeling to be used in optimizing combustion devices here on Earth."

A team of researchers from the University of Nebraska – Lincoln, led by Dr. George Gogos, is conducting a comprehensive computational study of fuel droplet combustion at atmospheric pressure and zero-gravity ambient conditions under forced convection. Through a collaborative effort with NASA Glenn Research Center, Dr. Gogos and his colleagues are developing a science education component that demonstrates how the combustion process changes due to microgravity.

Simplified as well as detailed chemical kinetics are employed in the research. The studies provide insights that can be applied to improve liquid fuel combustion with greater efficiency and safety, and reduce environmentally-adverse effects. In view of the detailed chemical kinetics, substantial complexities and uncertainties are involved in modeling combustion of a moving droplet through the currently finding experimental research on combustion of a moving droplet through the Microgravity Combustion Science Program.

The research focuses on the validated modeling of two key topics: a) Transient combustion of a moving droplet with simplified chemical kinetics; and b) Transient combustion of a moving droplet with detailed chemical kinetics. The first topic is currently being addressed, whereas the second one is a longer-term research project. This work is a direct extension of research funded by the NASA Nebraska Space Grant and EPSCoR Programs. "Dr. Gogos'

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studies on droplet combustion at atmospheric pressure include combustion of moving droplets with infinitely fast kinetics as well as with one-step global kinetics" (Bowen, Holmes, et al. 1999, p. 19).

Research success depends on the team's considerable experience combined with recently published studies on comprehensive modeling of hydrocarbon oxidation, which employ detailed chemical kinetics. Dr. Gogos' assistant, Dr. Daniel Pope, is also supported under the NASA Nebraska Space Grant and EPSCoR Programs. He has been working for over two years simulating combustion of a moving droplet with one-step kinetics and contributes immensely to the timely completion of the proposed work.

Research Progress

The current CEFD CRT research has focused on the development of a validated numerical model for droplet combustion in a forced convection environment. Funded by the previous five-year NASA EPSCoR grant, a quasi-steady numerical model, which utilized one-step overall chemical kinetics and a single diffusion coefficient to describe the mass diffusion, was developed to study the convective extinction of fuel droplets under zero-gravity conditions (Gogos, Pope, & Lu, 2001, p. 2). As a result of suggestions made in the review of the 2001 Pope and Gogos article and as a prelude to incorporating multi-step chemical kinetics schemes, the quasi-steady code is currently being modified to allow for the different mass diffusion coefficients associated with each pair of chemical species. This modification to the quasi-steady code is part of the systematic addition of modeling complexities that was presented in the original research proposal. The end goal of the research is to develop an experimentally validated droplet combustion model that can be used for accurate predictions of single droplet behavior in practical combustion systems.

The conditions present in convective droplet combustion experiments are different from those present in practical combustion systems. Droplet combustion experiments under forced convection are conducted by suspending the fuel droplet from a silica fiber in an ambient oxidizer at a fixed temperature ($T\infty$) and pressure ($p\infty$), as shown in Figure 1. The oxidizer is "blown" over the droplet at some fixed velocity ($U\infty$). If the ambient temperature is high enough, or if an external ignition source is present, the droplet will ignite. The initial flame configuration (wake, transition, or envelope) depends on the "blowing" velocity. In practical combustion systems, droplets are injected into a combustion chamber. This situation is shown in Figure 2, where the droplet is injected, at some initial velocity, into a stagnant environment at a specified temperature and pressure. The moving droplet experiences a drag force that opposes its motion and the droplet velocity decreases. The initial velocity determines the initial flame configuration. If the initial flame configuration is a wake flame, the decrease in droplet velocity can result in a change from a wake to a transition flame, and finally to an envelope flame. The numerical model must be able to deal with both the suspended droplet case (for model validation) and the moving droplet case (for practical predictions). A transient code is required to model the change in droplet diameter caused by evaporation at the droplet surface, the change in flame position and configuration, the internal heating of the droplet, and the decrease in droplet velocity for the moving droplet.

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A transient code has been developed to model droplet combustion in a forced convection, zero-gravity environment. One-step overall chemical kinetics and a single diffusion coefficient to describe the mass diffusion were used in the model. The model has been validated using the numerical results of the 2001 Gogos and Zhang research for the evaporation (no combustion) of n-heptane droplets in nitrogen at atmospheric pressure. Excellent quantitative agreement was observed for various ambient temperatures and initial droplet velocities.

The transient code has been used to numerically investigate the combustion of n-heptane droplets in air at atmospheric pressure. The initial droplet diameter (D0 = 0.5mm), initial droplet temperature (T0 = 297K), and the ambient temperature (T∞ = 1000K) were fixed and the initial droplet velocity (U∞(0)) or "blowing" velocity (U∞) was varied. Results have been obtained for moving and suspended droplets with initial Reynolds numbers of 10, 25, 50, and 100. At a given initial Reynolds number, the fixed "blowing" velocity (suspended droplet) and the initial droplet velocity (moving droplet) are equal. The numerical results indicate that the initial Reynolds number determines the flame configuration that forms during droplet ignition for both moving and suspended droplets. An envelope flame is formed during droplet ignition for an initial Reynolds number of 10 and a wake flame is observed at the higher initial Reynolds numbers. This is in qualitative agreement with the quasi-steady code, which predicts an envelope flame for Reynolds numbers less than 12 under these same conditions. Once the initial flame configuration had formed (either envelope or wake), the suspended droplet cases exhibited the same flame configuration throughout the droplet lifetime. In the moving droplet cases, the wake flame that formed at the higher initial Reynolds numbers, gradually approached, and then eventually surrounded the droplet in an envelope flame configuration as the droplet velocity decreased. The predictions indicate a marked difference between the behavior of suspended and moving droplets.

The development of a transient droplet combustion code represents a significant step in our current research which is funded by the new five-year NASA EPSCoR grant. The modification of the quasi-steady code to include multiple diffusion coefficients is nearing completion. Once this modification is tested, it will be incorporated in the transient model. The next step will then involve the incorporation of multi-step chemical kinetics in the quasi-steady and transient models.

Additionally, a computer code has been developed to study the combustion of liquid fuel droplets in a combustion chamber. Figures 3-5 show numerical results for the temperature distribution surrounding a n-heptane fuel droplet that is moving through a combustion chamber at three different velocities. The droplet diameter is 500 microns and the temperature and pressure of the combustion chamber are 1200 Kelvin and 1 atmosphere respectively. The color bar to the right of each figure indicates the temperature range (500 to 2500 Kelvin). Figure 3 corresponds to the lowest velocity shown. At lower velocities, the flame (high temperature region) surrounds the droplet in what is called an envelope flame. As the velocity is increased (Figure 4), the flame extinguishes near the front of the droplet. Further increases in the velocity (Figure 5) cause the flame to move toward the rear of the droplet forming a wake flame.

2001-2002 Progress

The CEFD CRT has made substantial progress in 2001. Two major aspects have been added to the validated axisymmetric quasi-steady code for the combustion of a moving droplet. First, the assumption of a single mass diffusion coefficient has been relaxed. The current code allows for different multicomponent diffusion coefficients. Second, the quasisteady assumption has been relaxed. The current transient code can predict, for example, how a moving droplet with a wake flame configuration, transitions to a droplet surrounded by an envelope flame, as the droplet decelerates due to the drag it experiences. These added aspects are presented in more detail below.

I. Numerical Simulation of Droplet Combustion in a Forced Convection Environment; Multicomponent Diffusion Coefficients.

Over the past few years, a quasi-steady numerical model has been developed to investigate fuel droplet combustion under forced convection in a low-pressure zero gravity environment. Two key assumptions used in the quasi-steady model were; (1) a one-step overall reaction was used to describe combustion, and (2) all binary diffusion coefficients were assumed to be equal. In the original code, the values for the activation energy, and oxygen and fuel concentration exponents in the finite-rate kinetics were adopted from Westbrook and Dryer. The pre-exponential factor was determined by comparison of numerical results with experimental data for extinction velocity.

For n-heptane, a pre-exponential factor three times that of Westbrook and Dryer was selected. The new code uses the same kinetics (including the pre-exponential factor) as Westbrook and Dryer. The assumption of a single binary diffusion coefficient (along with neglecting pressure and thermal diffusion) results in Fick's Law for the diffusion velocity of each species. The binary diffusion coefficient for the fuel and oxidizer was used in the code and was evaluated as a function of the local temperature. Due to these assumptions, the numerical predictions were only in qualitative agreement with experimental results from the literature. The new code employs the Stefan-Maxwell equations to allow for different multicomponent diffusion coefficients. Employing these changes, the new code matches experimental data for the extinction of n-heptane droplets.

II. Numerical Model for Droplet Combustion in a Forced Convection Environment; Transient Effects.

This part of the CEFD CRT research has focused on the development of a numerical model to study the flame transition during fuel droplet combustion under forced convective environment. Based on a quasi-steady numerical model, which utilized staggered numerical grid and neglected heat transfer to droplet interior, a transient code has been developed to model droplet combustion in a forced convection, zero-gravity environment. A colocated numerical grid, one-step overall chemical kinetics and a single diffusion coefficient to describe the mass diffusion were used in the transient model.

Numerical results indicate that at the same ambient temperature, the Reynolds number determines the flame configuration that forms during droplet ignition for both suspended and moving droplets. In both cases, an envelope flame was formed during droplet ignition for a low initial Reynolds number (such as Re = 10), and a wake flame was observed at higher Reynolds numbers (such as Re = 50). In the suspended droplet combustion case (Figure 1), the wake flame configuration was observed throughout the droplet lifetime, while for the moving droplet case (Figure 2), as the initial wake flame gradually approached the droplet, an envelope flame might eventually be formed due to deceleration of the droplet. Reynolds number not only determines the flame configuration, but also affects the initial flame location (ignition location).

The results for moving droplet combustion indicated that both initial Reynolds number and ambient temperature affect the ignition location. A high initial Reynolds number tended to make the droplet ignite further away from the droplet in the downstream direction. For higher ambient temperatures, the flame tended to initiate at locations closer to the droplet. The transient model predicted a marked difference between the behavior of suspended and moving droplets and shows the effects of both initial Reynolds number and ambient temperature on the flame configuration and ignition location.

Research Outcomes

The CEFD CRT meets weekly to allow researchers to present and discuss their new results. This ensures that research objectives are being met. For additional dissemination of findings, this CRT is in formal collaboration with both the John Glenn Research Center at Lewis Field in Ohio and the U.S. Department of Defense. Continued communication is a priority for the CEFD team. Additionally, Principal Investigator Gogos' has maintained direct communication with Dr. Vedha Nayagam in San Diego, California. This communication allows the CEFD CRT's modified numerical code to be validated by Dr. Nayagam's experimental data. Dr. Vedha Nayagam serves as the CEFD technical monitor through his experiences at the National Center for Microgravity Research. The CEFD team's numerical model is validated using experimental data obtained by Dr. Nayagam.

A post doctorate research associate, Dr. Daniel Pope, and a research assistant professor, Dr. Hongtao Zhang, are also participants in this research project. Both researchers have set goals of becoming tenure track faculty in institutions of higher education. The weekly research meetings provide both Dr. Pope and Dr. Zhang with invaluable experience on graduate student advising. Pope and Zhang are strongly involved in every aspect of the CEFD research faculty such as, writing proposals, writing papers, presenting conference papers, and reviewing papers. Such mentoring opportunities are expected to continue throughout the lifetime of the research study.

NASA EPSCoR funding has allowed for a variety of CEFD research activities. Those include the financing of travel to present papers as well as to attend conferences and workshops. Such papers and other substantial efforts are listed in the CEFD Team Outcomes (Appendix A). Student assistantships and computer services have also been made available. Additionally, the CEFD CRT investigations have resulted in the conference of the degree Master of Science to three research assistants: S.H. Soh, Y. Shi, and K. Lu.

Conclusion

The Numerical Simulation of the Combustion of Fuel Droplets study is one of three Collaborative Research Teams (CRT) currently supported by the NSGC & EPSCoR programs. Each CRT strives to provide the most current information to interested members of the academic world. The Numerical Simulation of the Combustion of Fuel Droplets study is an evolving project. Periodic updates are available on a quarterly basis.

Additional collaborations are sought with other organizations on a continual basis. All opportunities for collaboration are invited for consideration. Additionally, NSGC & EPSCoR welcome any input on program directions as well. The partnership between the NSGC & EPSCoR programs allows for the selection of outstanding research projects that positively impact aeronautical technology advancement. Those in the NSGC & EPSCoR program, the Collaborative Research Teams, and the industry look forward to experiencing the same high level of achievement in the future. A listing of CEFD CRT Team Outcomes can be found in Appendix A.

Recent Activities

1. Weekly CRT meetings to present and discuss new results.
2. This CRT is in formal collaboration with the John Glenn Research Center at Lewis Field in Ohio.
3. This CRT is in formal collaboration with the U.S. Department of Defense.
4. Principal Investigator Gogos' has maintained direct communication with Dr. Vedha Nayagam in San Diego, California.
5. Dr. Vedha Nayagam serves as the CEFD technical monitor through his experiences at the National Center for Microgravity Research.
6. Dr. Daniel Pope and Dr. Hongtao Zhang are gaining invaluable experience on graduate student advising through CRT weekly meetings.
7. This research has allowed for the financing of travel to present papers as well as to attend conferences and workshops.
8. Student assistantships and computer services have also been made available through this CRT.
9. The CEFD CRT investigations have resulted in the conference of the degree Master of Science to three research assistants: S.H. Soh, Y. Shi, and K. Lu.

Further Information

If you would like further information regarding the Numerical Simulation of the Combustion of Fuel Droplets, or would like to collaborate with the Nebraska CRT, please contact:

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This overview was prepared and regularly updated by Dr. George Gogos, Dr. Brent Bowen, and Mrs. Jocelyn Nickerson, with contributions from various CEFD CRT members.

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- Director of the NASA Nebraska Space Grant & EPSCoR
- Principal Investigator of the primary funding source, the NASA Nebraska EPSCoR Program

Staff Support:

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Mrs. Jocelyn Nickerson

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- Graduate Research Assistant, Mechanical Engineering Department at UNL

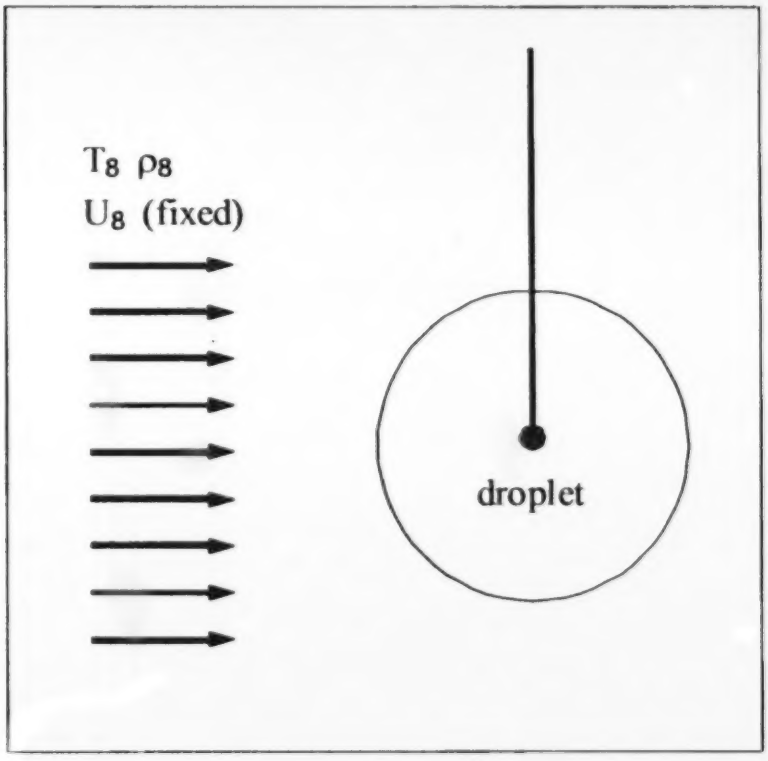
Mr. Kun Lu

- Graduate Research Assistant, Mechanical Engineering Department at UNL

Figure Caption

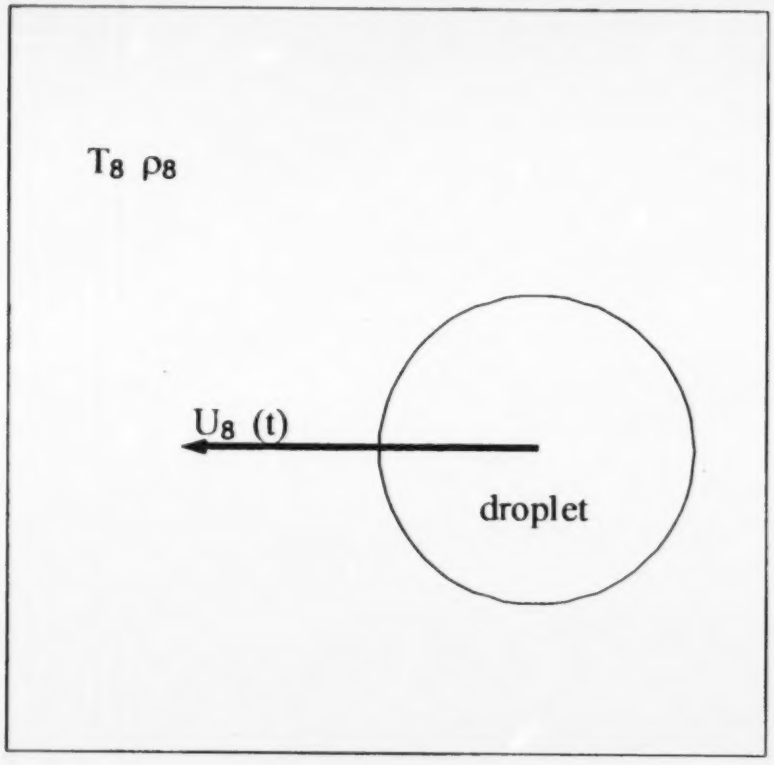
Figure 1. Orientation of single droplets for experiments
Figure 2. Orientation of single droplets within practical combustion systems
Figure 3. Numerical results for the temperature distribution surrounding a n-heptane fuel droplet that is moving through a combustion chamber at a velocity of 3.25 m/s
Figure 4. Numerical results for the temperature distribution surrounding a n-heptane fuel droplet that is moving through a combustion chamber at a velocity of 5.86 m/s
Figure 5. Numerical results for the temperature distribution surrounding a n-heptane fuel droplet that is moving through a combustion chamber at a velocity of 3.25 m/s

Figure 1: Orientation of single droplets for experiments



Suspended Droplet

Figure 2: Orientation of single droplets within practical combustion systems



Moving Droplet

Figure 3: Fuel droplet velocity 3.25 m/s

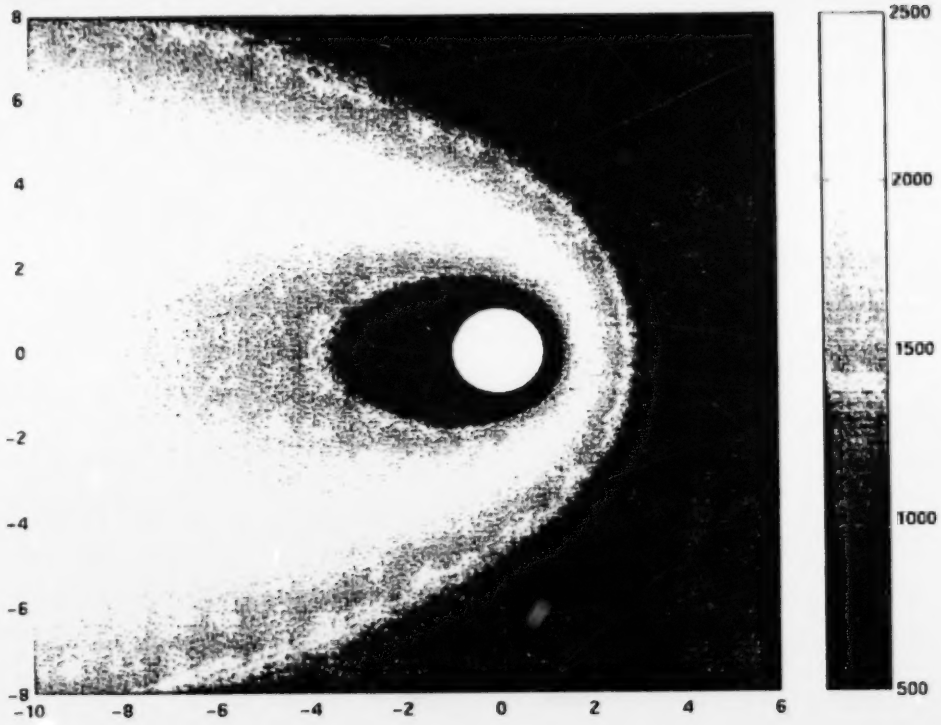


Figure 4: Fuel droplet velocity 5.86 m/s

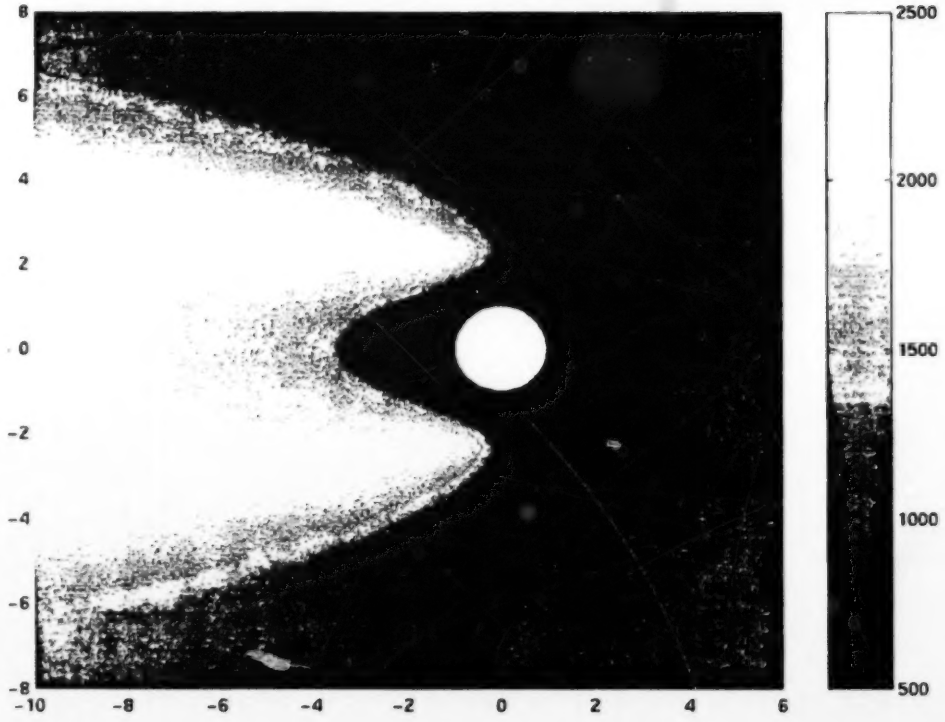
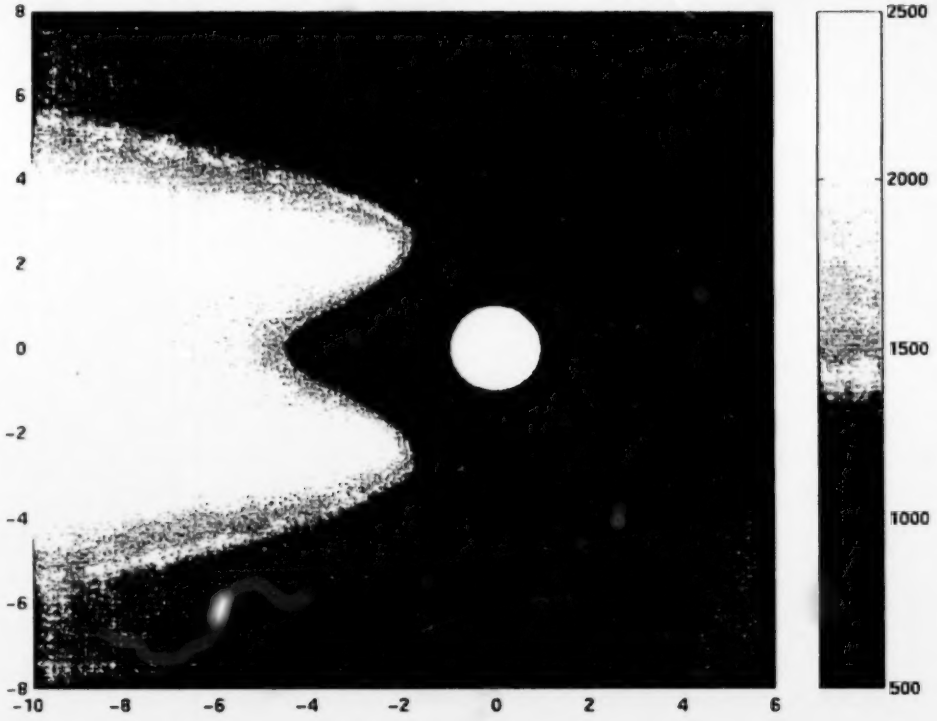


Figure 5: Fuel droplet velocity 8.13 m/s



Appendix A

Team Outcomes

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THE SMALL AIRCRAFT TRANSPORTATION SYSTEM (SATS): RESEARCH COLLABORATIONS WITH THE NASA LANGLEY RESEARCH CENTER

A NASA Nebraska Space Grant & EPSCoR Sponsored Research Endeavor

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Abstract

The aviation industry is an integral part of the world's economy. Travelers have consistently chosen aviation as their mode of transportation as it is reliable, time efficient and safe. The outdated Hub and Spoke system, coupled with high demand, has led to delays, cancellations and gridlock. NASA is developing innovative solutions to these and other air transportation problems. This research is being conducted through partnerships with federal agencies, industry stakeholders, and academia, specifically the University of Nebraska at Omaha. Each collaborator is pursuing the NASA General Aviation Roadmap through their involvement in the *expansion of the Small Aircraft Transportation System* (SATS). SATS will utilize technologically advanced small aircraft to transport travelers to and from rural and isolated communities. Additionally, this system will provide a safe alternative to the hub and spoke system, giving more time to more people through high-speed mobility and increased accessibility.

THE SMALL AIRCRAFT TRANSPORTATION SYSTEM (SATS): RESEARCH COLLABORATIONS WITH THE NASA LANGLEY RESEARCH CENTER
(White Paper)

An Overview of Capabilities

Rationale

The aviation industry is an integral part of the world's economy. Travelers have consistently chosen aviation as their mode of transportation as it is reliable, time efficient and safe. They are encouraged to use aviation in its varied forms for both business and personal purposes. However, commercial airlines are required to follow routes that have been designated by the out-dated Hub and Spoke system. This, coupled with high demand, has led to delays, cancellations and gridlock.

The need for efficient options for business and personal travel is anticipated to increase steadily. Yet even as the airline hubs become more and more crowded, there seems to be no immediate answer to the problem. This system emphasizes large airports and large aircraft, and requires travelers to fly long distances through metropolitan areas to be advantageous. Airline management will find their customers becoming increasingly frustrated by increases in both safety and congestion problems. The decrease in customer satisfaction and overall efficiency will lead to loss of revenue, opportunities and time.

Those passengers who are repeatedly disappointed by what is currently available will seek other avenues of travel. Perhaps consumers will look to the five thousand small airports throughout the United States to alleviate their transportation problems. Unfortunately, travelers will find that no business strategies have been created and no federal funding has been delivered to address the air transport needs of rural and isolated communities. Even the Federal Aviation Administration lacks the budget to deliver the efficiencies that the aviation industry demands. Without additional business, these small airports will remain underutilized.

The SATS Concept

The National Aeronautics and Space Administration (NASA) is developing innovative solutions to these and other air transportation problems. This research is being conducted through partnerships with federal agencies, industry stakeholders, and academia, specifically the University of Nebraska at Omaha. Each collaborator is pursuing the NASA General Aviation Roadmap through their involvement in the expansion of the Small Aircraft Transportation System (SATS).

SATS is intended to utilize technologically advanced small aircraft to transport travelers to and from rural and isolated communities. Additionally, this system will provide a safe alternative to the hub and spoke system, giving more time to more people through high-speed mobility and increased accessibility. The benefits of SATS include, but are not limited to, economic development, intermodal connectivity and a revolution in exportable transportation.

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Those who created this concept recognized the importance of time and remained sensitive to how long the execution of this system would take. Therefore, the SATS researchers set a goal in 1999 to reduce public travel time by half in ten years and two-thirds in 25 years. Additionally, this would be completed at equivalent highway system costs, increasing mobility for all of the nation's communities through advanced on-demand air transportation. The envisioned outcome is to increase "connectivity" between remote communities and transportation centers in urban areas by utilizing the nation's 5,400 public-use general aviation airports. This allows isolated communities to receive safe, affordable and timely transportation. Those working on the development of this project have remained faithful to this timeline and fully expect this goal to be accomplished.

Nebraska SATS Collaborative Research Team (CRT)

The Small Aircraft Transportation System Collaborative Research Team (SATS CRT) is highly productive in its research endeavors. This CRT develops and implements a research agenda to support SATS research activities at NASA's Langley Research Center (LaRC). Although the SATS CRT work clearly focuses on SATS, it is not confined to a single discipline or topical area. Research projects undertaken by CRT members include systems engineering and decision support analysis, policy analysis, network development research, and financial analysis. In each case, the SATS team is progressing towards its larger objective of conducting research that is both credible and useful to decision makers within and outside NASA. The SATS CRT has produced a number of research outcomes related to its work in Year 1. The SATS CRT has secured non-EPSCoR funding through its participation in the North Carolina – Upper Great Plains SATSLab team, which is led by the Research Triangle Institute.

Scott Tarry has replaced Russell Smith and is working to coordinate the activities of the CRT so they are both responsive to the various needs expressed by the NASA SATS team at LaRC and part of a coherent and complementary research agenda. Tarry maintains regular contact with SATS officials at LaRC and executes regular meetings of UNO SATS researchers and support staff. Tarry met with Bruce Holmes, who replaced Mike Durham as Technical Monitor in January at the Transportation Research Board Meetings in Washington, DC. In addition to these administrative functions, Tarry oversees three projects. The first examines SATS as a policy alternative to Essential Air Service, which is the government subsidized program that provides air service to small communities. Understanding whether small communities and national policy makers will accept SATS as credible and reliable for small community air service will determine whether it will succeed as a transportation system for ordinary Americans. The second project focuses on insurance and endeavors to determine whether insurance costs associated with SATS aircraft and operational characteristics will present a critical barrier to the successful implementation of the system. Finally, Tarry is supervising the work of Patrick O'Neil, a PhD student in Public Administration. O'Neil has prepared an annotated bibliography on technologies that are relevant to flight operations in the SATS program. O'Neil met with NASA Langley researchers in the initial stages of his project. The bibliography was submitted to LaRC for use by researchers at NASA in SATSLab teams that are engaged in the flight demonstration projects.

The SATS CRT's focus is on the implementation of a transportation system that will enhance economic development opportunities for the people of Nebraska, especially those living in small communities and rural areas where air transportation services are inadequate or nonexistent. Working with the Nebraska Department of Aeronautics and other relevant state officials, the CRT believes its research will have a real and significant impact on the quantity and quality of air transportation services in the state.

Individual Contributions to the SATS Project

Massoum Moussavi aids in LaRC's on-going effort to develop a computer-based decision support system/model for SATS implementation. The focus of Moussavi's research is the implementation of this model for managing SATS planning, design, and operation within the State of Nebraska. A direct outcome from these efforts is the Master's thesis by Moussavi's student, Jaime Vargas, who received his MS in Civil Engineering in May 2002. Vargas developed important sub-models for the more comprehensive decision support model. His sub-models of demand forecasting, airfield, terminal, and ground transportation provide a solid foundation for the larger project. Moussavi continues his own efforts to develop a number of other sub-models, including mobility, accessibility, and travel time. Moussavi also contributes to the SATS assessment and analysis work conducted at LaRC and is in regular contact with Jerry Hefner and Stuart Cooke, Jr., who lead that effort for NASA's SATS team. Moussavi coordinates research conducted by other team members, so that the team's diverse research projects contribute to the decision support model development efforts in Nebraska and at the national level.

Brent Bowen is contributing to the SATS team through his efforts on two projects. First, he oversees the CRT's analysis of security issues related to general aviation. It is clear that security issues are of increased operational and political importance in the current environment. Second, Bowen continues to coordinate research on SATS policy issues, which include papers in process regarding a critical review of SATS program development and recommendations for future direction and evaluation. Bowen is also exploring the organizational transition from AGATE to SATS in an effort to understand lessons that can be learned from the AGATE experience and integrated into the successful development of the SATS Consortium, which will consist of government, industry, and academic partners. This work is facilitated by a research fellowship awarded to Nanette Scarpellini-Metz. Metz visited LaRC in the summer of 2001 where she interviewed key participants in AGATE and SATS and collected archival data related to the development of AGATE and the transition to SATS.

John Bartle continues his work on financial issues related to SATS implementation. Bartle's work is important for the successful development of the decision support model noted above, since financial constraints appear to be among the most critical barriers to implementation of SATS in rural and isolated communities, where SATS is especially relevant for Nebraska and the Great Plains region. Bartle's work relies on the Nebraska State Aviation System Plan (NSASP), which is in the final stages of revision. The NSASP will allow Bartle to match the financing options he has been evaluating with the specific needs of airports and communities in the Nebraska aviation system. This work has been slowed by the delayed official release of the

NSASP, but promises to be a real and credible contribution to understanding important implementation issues in Nebraska and around the nation.

Scott Tarry is also overseeing the development of an educational web site, known as SATS 101, which is designed to provide information about SATS that can be used by students, policy makers, and the general public. Russell Smith continues to develop the survey instrument he will use to study the prospects for the development of regional organizations that could enhance the coherent development of SATS as a regional transportation system. John Bartle continues to explore airport funding issues as they relate to the implementation of SATS. The release of the recently completed Nebraska State Aviation System Plan will provide important inputs for Bartle's study. Brent Bowen oversees the work of Todd Bonkiewicz, UNO graduate student, who is exploring the issue of general aviation security with the objective of providing a foundation of knowledge from which the security implications for SATS can be more carefully assessed and understood. Scott Tarry is overseeing the work of Pat O'Neil, a PhD student who has compiled an annotated bibliography of flight technology research relevant to SATS.

Progress of the SATS CRT is currently monitored through group and individual meetings. These meetings allow members of the SATS team to compare their progress with the expectations and objectives established in the CRT's original proposal. Evaluations are based on the quality and quantity of research outcomes, such as conference papers and published manuscripts.

Collaborative Efforts

The SATS CRT has partnered with a variety of academic institutions and organizations supporting the aerospace industry. Specific collaboration has been established and continues to flourish between the SATS CRT and the Aviation Institute and the School of Public Administration, which are both housed on the University of Nebraska at Omaha campus. Additionally, Massoum Moussavi maintains collaboration by representing the University of Nebraska at Lincoln's College of Engineering. A mutually beneficial relationship has also been established with Shelly Avery of the Nebraska Indian Community College in Macy, Nebraska.

On a national level, collaboration has been established with NASA's Langley Research Center in Hampton, Virginia. The SATS CRT recognizes the importance of maintaining continuous contact with NASA, and specifically with NASA Langley Research Center (LaRC), in Hampton, Virginia. Jerry N. Hefner, Manager of SATS Transportation Systems Analysis and Assessment, has become the SATS CRT primary contact at LaRC, while Stuart Cooke, Jr. has provided guidance regarding systems engineering. The SATS CRT is working to be responsive to needs of the SATS team at NASA LaRC. Continued emphasis will be placed on policy, finance, and systems assessment, although specific research objectives may change. Such changes will be coordinated with the SATS team at NASA LaRC.

Collaboration has also been maintained with the NASA Nebraska Space Grant Consortium (NSGC). The NSGC provides additional funding for support of SATS CRT researchers and staff. Additionally, the Nebraska Department of Aeronautics' Director, Kent

Penney, and State Airport Engineer, Diane Hofer, assist the SATS CRT with data and other research materials related to the Nebraska Aviation System Plan and aeronautics issues in the state.

Community and Educational Outreach

UNO SATS research is designed to provide support to the SATS concept through extensions of research activities. With new technologies and available information, the World Wide Web can play a greater role in communicating SATS information. The Nebraska SATS website (www.unomaha.edu/~unoai/sats/) educates system users, provides support to academic classroom activities, and serves as a discussion forum for all parties or stakeholders. Additionally, this support component encompasses public appearances to interested parties, hosting information booths, participating in national and regional conferences, and developing an on-line SATS course.

Personnel from this component are developing a SATS educational outreach pilot program. This consists of workshops and hands-on experiences for Native Americans and other minorities in cooperation with the NSGC Nebraska Native American Outreach Program's (NNAOP) Family Science Initiative. The SATS CRT will continue to work with UNO's NNAOP personnel, led by Dr. Hank Lehrer, Principal Investigator. The NNAOP has established a variety of on-going, successful programs for Nebraska's Native American populations. SATS CRT members have established a SATS related curriculum for integration into the NNAOP Family Science Initiative. Members of the team are planning visits to Nebraska's Native American public schools to introduce SATS to tribal children and their families.

Efforts for educational outreach in the first year evolved from a state mission to a regional mission. Nebraska now plans for national level involvement with a national SATS symposium. Nebraska program staff work closely with Dr. Thomas Pinelli and Mr. Roger Hathaway in the Office of Education at NASA LaRC to ensure that the most up-to-date information is available for program effectiveness. All published material on SATS will be provided to the National Transportation Library for on-line dissemination, archived at the University of Nebraska at Omaha Library, and abstracted in key international databases.

Public outreach and education has been a priority for the SATS team. CRT members have presented SATS related work to a number of different audiences in Nebraska and around the nation. The CRT is also preparing a web-based instructional curriculum (SATS 101), which can be used by educators interested in teaching about air transport and SATS or by members of the general public who are interested in learning more about the project.

Technological Efforts

The SATS CRT continues to maintain a website related to its research projects and outcomes. A variety of proposal and symposium materials are available on this website as well. The CRT also publicizes its SATS research and the SATS program generally though the distribution of CDs, NASA EPSCoR brochures, other SATS images and logos.

The SATS CRT is in the process of developing an educational and informational web site called SATS 101. Graduate and faculty researchers are drawing from their various SATS research projects to present relevant information to the public in an interesting and accessible format. It is anticipated that this website will be up and running by May 1, 2003.

Diversity Initiatives

Conscious efforts have been made to ensure the participation of underrepresented groups in the SATS CRT. Women are represented at all levels of the CRT, including staff researchers, graduate assistants, and faculty researchers. Michaela Schaaf, Research Associate and Instructor, is being mentored by Brent Bowen. Minority groups, Hispanics and Native Americans, are represented as well. Efforts to identify and recruit additional CRT members from underrepresented groups is a priority of this research program.

SATS CRT Outcomes

The CRT is seeking to develop roles for two new junior faculty members. Mike Larson of the UNO Aviation Institute and Kenneth Kriz, who was recently hired to join the UNO Department of Public Administration, are being groomed for these positions.

The SATS CRT is participating in the North Carolina / Upper Great Plains (NC/UGP) SATSLab Team that was awarded a contract from NASA to pursue research related to the demonstration and implementation of SATS technologies. Scott Tarry, representing the UNO Aviation Institute, is serving as principal investigator on a $100,000 sub-contract from team lead Research Triangle Institute. The purpose of the sub-contract is to fund initial studies related to systems assessment and analysis. The research will continue throughout 2002 as NASA has extended the deadline for this work. The SATS CRT plans to continue its participation in the NC/UGP SATSLab Team as NASA's SATS demonstration project expands towards its ultimate 2003 flight test objective.

The SATS CRT's work has been publicized in both UNO and UNO press releases and has received coverage in the Omaha World Herald. The CRT's work has also been reported in various trade publications and newsletters. The CRT will continue its efforts to publicize its research findings and disseminate its results globally. A complete listing of SATS CRT Team Outcomes can be found in Appendix A.

Aviation Safety

The Nebraska SATS initiative has begun to explore aviation safety components affected by comprehensive systemic change. This initial investigation is coordinated with the NASA LaRC SATS Program and in consultation with Mike Durham, NASA LaRC Aviation Safety Program liaison to SATS. Candidate areas of focus include, but are not limited to, areas such as bio-medical and human factors, maintenance, manufacturing, support systems, airport environment, pilot education and regulatory issues impacting safety. Nebraska, as co-lead for

the NASA Space Grant/EPSCoR Aeronautics Program, will seek to engage other space grant and EPSCoR states in this area of inquiry.

Conclusion

The implementation of SATS would be a dream come true for communities that urgently need air service and medical air transport. This system is a clear concept, made credible by extensive research. Although SATS is not an additional system for commercial airlines, it should be viewed as a component of aviation, which will help alleviate congestion at airline hubs to allow for increased customer satisfaction. This safe travel alternative will free both passengers and products from transportation system delays. SATS will better serve existing markets and extend air service to communities currently neglected by the airline industry. This will be accomplished through the use of advanced small aircraft, new innovations in navigation and communication technologies, and new business models.

SATS has the potential to dramatically improve access to small and isolated communities while developing over 5000 general aviation airports into operational business centers. New consumers and producers will be linked to the global economy rather than being confined to their immediately surrounding areas. Time is of the essence in the SATS endeavor. The opportunity to educate the public is upon us. When this phase of implementation is complete, travelers will be more knowledgeable of their transportation options and more able to actively participate in saving the future of transportation.

Recent Activities

1. Development of a research agenda to support SATS research activities at NASA's Langley Research Center (LaRC).
2. Research projects undertaken by CRT members include systems engineering and decision support analysis, policy analysis, network development research, and financial analysis.
3. The SATS CRT has secured non-EPSCoR funding through its participation in the North Carolina – Upper Great Plains SATSLab team, which is led by the Research Triangle Institute.
4. Tarry maintains regular contact with SATS officials at LaRC and executes regular meetings of UNO SATS researchers and support staff.
5. Tarry met with Bruce Holmes, who replaced Mike Durham as Technical Monitor in January 2002
6. Tarry oversees three projects:
    a. SATS is examined as a policy alternative to Essential Air Service.
    b. Insurance and insurance costs associated with SATS aircraft and operational characteristics are examined.
    c. Preparation of an annotated bibliography on technologies that are relevant to flight operations in the SATS program.
7. Moussavi has developed a computer-based decision support system/model for SATS implementation.

8. Vargas has developed important sub-models of demand forecasting, airfield, terminal, and ground transportation provide a solid foundation for the larger project.
9. Moussavi is in regular contact with Jerry Hefner and Stuart Cooke, Jr.
10. Brent Bowen oversees the CRT's analysis of security issues related to general aviation.
11. Bowen continues policy research initiatives, which include papers in process regarding a critical review of SATS program development and recommendations for future direction and evaluation.
12. Bowen is exploring the organizational transition from AGATE to SATS to understand lessons that can be learned from the AGATE experience and integrated into the successful development of the SATS Consortium.
13. John Bartle continues his work on financial issues related to SATS implementation.
14. Russell Smith is developing a survey instrument utilizing Delphi techniques in preparation for his study of regional network development as it relates to air transportation in Nebraska and the Great Plains.
15. Smith continues to work with the Nebraska Department of Aeronautics Director, Kent Penney, to identify state and university collaborations on the SATS project.
16. CRT members have presented SATS related work to a number of different audiences in Nebraska and around the nation.
17. The CRT is preparing a web-based instructional curriculum (SATS 101), which can be used by educators interested in teaching about air transport and SATS or by members of the general public who are interested in learning more about the project.
18. Collaborations are maintained with Shelly Avery at the Nebraska Indian Community College.
19. Collaborations are maintained with Bruce Holmes in the General Aviation Program Office at Langley Research Center.
20. Collaborations are maintained with Stuart Cooke in the Systems Engineering Department at Langley Research Center.

A proposal for $37,000 has been submitted to NASA via the Research Triangle Institute.

Further Information

If you would like further information regarding the Small Aircraft Transportation System, or would like to collaborate with the Nebraska CRT, please contact:

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This overview was prepared and regularly updated by Dr. Scott Tarry, Dr. Brent Bowen and, Mrs. Jocelyn Nickerson, with contributions by various SATS CRT members.

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- Principal Investigator of the primary funding source, the NASA Nebraska EPSCoR Program

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- Technology Manager at the University of Nebraska at Omaha Aviation Institute

Appendix A

Team Outcomes

Development of two new junior faculty members; Mike Larson of the UNO Aviation Institute and Kenneth Kriz of the UNO School of Public Administration.

The SATS CRT is participating in the North Carolina / Upper Great Plains (NC/UGP) SATSLab Team that was awarded a contract from NASA to pursue research related to the demonstration and implementation of SATS technologies.

Scott Tarry is serving as principal investigator on a $100,000 sub-contract from team lead Research Triangle Institute.

Continued SATS SRT participation in the NC/UGP SATSLab Team as NASA's SATS demonstration project expands towards its ultimate 2003 flight test objective.

Master's thesis by Jaime Vargas who received his MS in Civil Engineering in May 2002.

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